Treatment Method

This invention relates to a method of and apparatus for treating products which are made of materials which are applied to a surface (which may be a mould surface which is subsequently removed) in a liquid form and thereafter have to dry or cure before the product is ready for use. Such materials will usually have a heterogenous structure. Examples of such products are those made from fibre reinforced plastics and plastered building walls, but the invention can have much wider application.

The invention is particularly suited for treating glass fibre boat hulls, but is not limited to this particular application. For convenience, the invention will largely be described with reference to its application to boat hulls but this is not to be taken as limiting the application of the invention, and those skilled in the art will be able to adapt the teaching here for use in connection with other products or structures.

Fibre reinforced plastics (FRP) boat hulls conventionally have a smooth outer gelcoat layer and a structural layer made up of fibres (usually glass fibres) embedded in a resin (most usually polyester resin). In some cases a foam or timber core is encapsulated between two reinforced fibre layers. The gelcoat and resin are initially liquids which are mixed with a hardener (catalyst) and applied within a mould in liquid state. After application, the liquids cure to the solid state.

After prolonged exposure in a marine environment, a number of boat hulls are found to suffer blistering which appears on the outer gelcoat surface. It appears that this is caused by a build up of fluid between the gelcoat layer

and the fibre/resin layer. The damage can result from one or more of the following: water penetration; degradation reactions resulting from water penetration; deterioration resulting from faulty manufacture; deterioration resulting from faulty materials used in the moulding process; deterioration resulting from failed bonding or de-lamination of foam or timber cores; de-lamination of the moulding. The symptoms of such damage are often attributed to "osmosis" but there is some doubt as to whether any or all of this damage is actually caused by an osmotic reaction.

Conventional treatment is to remove the affected gelcoat to expose the underlying fibre/resin lay-up, to thoroughly dry the exposed fibre/resin lay-up and then when drying is complete to reinstate the gelcoat, possibly with the addition of different resins to provide a better moisture barrier.

This treatment is sometimes, but by no means always, successful. It does however take a considerable amount of time because the resin/fibre lay-up can only be dried slowly, usually by allowing it to stand in the open.

According to the present invention, there is provided a method of treating a product moulded from fibre reinforced plastics, wherein the edges of a sheet of impermeable sheet material are secured to a surface of the product to be treated to enclose a space between the surface and the sheet, heating is applied within the space, and the gaseous contents of the space are continuously extracted while the sheet is held spaced from the surface to allow gas and vapour to be extracted from any area of the surface beneath the sheet.

The heating is preferably applied from a heat source within the space, but may also be applied from an external heat source, provided there is a thermally conducting path into the space, eg through a thermally conductive impermeable sheet material. In any case, some heat loss through the sheet material is desirable as this helps to maintain an even heat distribution within the space.

Preferably the sheet material has an area of up to 1 m^2, and can be of any convenient shape. The material is preferably secured to a part only of the product surface, and the entire product surface is preferably treated in a batch-wise manner by treating all the parts of the surface sequentially, or by securing a plurality of sheets simultaneously to different parts of the surface. Using a piece or pieces of sheet material of this size allows a boat hull to be treated section-by-section

The method will generally be carried out after the affected gelcoat, and any physically damaged material has been removed from the surface.

To maintain the space between the sheet and the surface, a permeable, substantially non-compressible spacer layer is preferably positioned between the sheet and the surface.

Extraction of the gaseous contents to form a vacuum (this term includes a partial vacuum) behind the sheet will pull the sheet against the spacer layer and (around the sheet edges) against the surface of the product to be treated to enclose a space adjacent the surface. It may be useful to initially secure the sheet to the surface by adhesive mastic or tape around the edges of the sheet to hold the sheet in place until the vacuum is applied. If there are any leaks around the edge of the sheet preventing the

maintenance of a suitable vacuum, adhesive tape or some other form of sealant may be applied around the edges.

The edges of the sheet may be of a soft, impermeable material which will be drawn against the surface when a vacuum is applied to form a seal without the need for any additional tape or sealant, or may have such a material sealed to the sheet edges.

A vacuum pump can be connected to the space to provide the extraction facility.

Tests have shown that the damage to the hull or other product does not only result from water penetration through the gelcoat, but also from unreacted chemicals in the gelcoat and in the fibre/resin layers. In some cases the resin is not completely cured at the time of manufacture, leading to the presence of reactive, but unreacted, chemicals in the structure.

By heating the laminate from the surface at the same time as drawing off any vapour or moisture from the surface, it is possible to ensure that any unreacted chemicals complete their reaction so that they become stable, at the same time as producing the necessary drying of the moulding. Once the drying is completed in this way, the removed gelcoat can be replaced with fresh gelcoat and the hull can be finished to complete the repair.

It is preferred to produce a vacuum in the space to a level of about 2 - 5 mb Abs, before beginning to apply heat within the space.

It is preferred to heat the surface within the space to a temperature which is just below the temperature at which

the moulding will be damaged by excess heat. In the case of polyester resins, the surface may be heated to a temperature between 80°C and 90°C which is a temperature at which the surface will not be at risk from damage caused by the elevated temperature. The elevated temperature however is effective in producing post-cure of any unreacted chemicals in the laminate. Higher temperatures may be used when the damage/deterioration is severe.

By continuously applying a very low pressure (high vacuum) to the space, vapour or gas is drawn off as soon as it becomes free at the surface, and also any gaseous reaction products are drawn off so that reactions take place quickly and thoroughly.

The invention also provides apparatus for treating a product moulded from fibre reinforced plastics, the apparatus comprising an impermeable sheet, means for securing the sheet to a surface of the product to be treated to enclose a space between the surface and the sheet, means for holding the sheet spaced from the surface to allow gas and vapour to be extracted from any area of the surface beneath the sheet, heating means for applying heat within the space and means for continuously extracting the gaseous contents of the space.

The means for spacing the sheet from the surface ensures that a space is maintained between the sheet and the surface, even when vacuum is applied. The spacing means may also space the heating means from the surface.

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The means for extracting the gaseous contents of the space is preferably a vacuum pump capable of working down to pressures of 5 to 2 mb Abs.

The heating means preferably includes a thermostat and a controller so that a constant temperature can be maintained within the space. The sheet may include thermal insulating material.

A treatment duration of about 1-2 hours may be sufficient to dry out an area of laminate about 0.5 m^2 .

The apparatus may include sheets of differing sizes and differing shapes, so that the method can be carried out on product areas of various shapes.

The invention will now be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a boat hull being treated by a method in accordance with the invention;

Figures 2, 3, 4 and 5 show impermeable sheets of various different shapes;

Figure 6 is a cross section through one form of apparatus in accordance with the invention;

Figure 7 is a cross section through a second form of apparatus in accordance with the invention; and

Figures 8a and 8b show details of an edge of the apparatus before and after application of vacuum.

Figure 1 shows a yacht hull 10 with a water line 12 and a keel 14. A damaged area of the hull is shown in dotted

lines at 16, and this area has been covered by an impervious sheet or mat 18 which is secured to the hull 10 all the way round by adhesive tape 20, or by a suitable mastic. Alternatively the sheet may have an edge of a material which will automatically form a seal when pulled against the surface by a vacuum. Thus the space between the hull and the sheet 18 is enclosed. A suitable material for the sheet is a silicone rubber.

Connected to the centre of the sheet 18 is an outlet 22 for a vacuum hose 24. Also connected to the sheet 18 is an electrical lead 26 which leads from a power supply 26b through a connection 26a to a heating element attached to the surface of the sheet 18 which will face the hull.

Figure 6 shows a cross section through the area covered by the sheet 18. A layer of permeable insulating material 30 (for example a non-woven permeable polyester blanket) is provided immediately underneath the sheet 18, and a heating element 32 is sandwiched between two heat resisting permeable layers 34, 36. The heating element 32 is connected to the electrical supply 26. In use, when suction is applied through the outlet 22, air and any other gaseous elements contained within the space beneath the sheet 18 will be sucked out. This will tend to pull the sheet 18 against the surface of the hull 10, but a spacing will still be maintained because of the presence of the permeable spacer 30, and because the heating element 32 itself is substantially incompressible and occupies space. As a result, the pump 38 will be able to draw off gas from the whole of the space beneath the sheet 18, and thus from all parts of the surface of the hull 10 which are exposed within the space.

Other parts of the hull can be treated at the same time by securing other sheets as described to the appropriate hull parts. One vacuum pump may serve to simultaneously evacuate several areas under treatment.

The heating element 32 is sandwiched between the layers 34 and 36, partly to protect the heating element itself and partly to avoid scorching the surface of the hull 10. However it is possible for the heating element to be in direct contact with the hull if the temperature of the heating element and the surface of the hull are compatible. The element 32 can be sewn to one or the other of the layers 34,36.

A thermostat 40 can be fitted in a position where it will be in contact with the hull surface 10 so that the hull temperature can be monitored.

The arrangement shown in Figure 6 provides a very flexible device which can follow complex hull contours. Figure 7 shows a somewhat less flexible alternative. In this alternative, instead of the permeable insulating spacer 30, a wire mesh spacer 42 is used, and in this case the spacer 42 lies against the hull surface and the heating element is fitted between the sheet 18 and the spacer. The wire mesh spacer 42 has flexibility, but less than that of the insulating sheet type spacer 30 of Figure 6.

As the hulls of boats are irregular shapes, and parts of the hull, for example close to the bow, may need to be treated, it may be useful to have sheets of different shapes.

Figure 2 shows a simple rectangular sheet 10b with rounded corners; Figure 3 a round sheet 10c; Figure 4 a triangular

sheet 10d and Figure 5 a long narrow sheet 10e. The sheet of Figure 5 can be used for example to treat areas of a hull between chines. The rounded corners of Figure 2 allow a single strip of mastic to be easily placed all the way around the edges of the sheet, thus avoiding air gaps. The other sheet shapes can also have rounded corners.

In use, a strip of adhesive mastic tape 20 (Figure 8a) is stuck to the edges of the sheet 18, and the sheet is secured to the damaged area of the hull (after removal of the damaged gelcoat) by this tape. A high vacuum is applied to the surface of the hull through the conforming flexible enclosure which has an underlying permeable spacer. The edges of the sheet are pulled down against the hull with the result that the tape 20 is compressed, as can be seen in Figure 8b. However the presence of the spacer 30, 42 ensures that there is always communication between the outlet 22 and all parts of the hull surface beneath the sheet. Heat is then slowly applied to raise the laminate to that temperature where the contaminants made volatile by the low pressure are drawn off.

The heater is equipped with a controller which maintains a steady temperature at which the moulding is likely to be completely cured or stabilised. The heat output is controlled to remain safely below the temperature at which the laminate would be damaged or affected by a serious loss of structural strength.

The temperature at which the laminate is maintained varies with the materials of the moulding. For example, a typical glass fibre reinforced polyester moulding would be maintained at a temperature between 82°C and 90°C.

After completion of treatment, the heater is switched off, the vacuum is released and the sheet is removed by peeling it away from the surface. The mastic tape 20 is removed and discarded. Before the sheet is applied to a new area of the surface, a fresh layer of tape is applied around the sheet edge.

The method and apparatus allows large mouldings to be effectively treated by means of moderately sized, easily handled enclosures. Although the technique has been particularly developed for use on boat hulls, it can also be used on other mouldings, for example fixed mouldings used in architecture, tanks or containments.

It has been found that glassfibre structures, treated in this way, experience some change in mechanical properties. It has surprisingly been found that treated structures have a greater stiffness in bending after treatment than before, while a small decrease in tensile strength has been noted. For boat hulls, stiffness in bending is important as this reduces flexing of the hull in a seaway.

The vacuum at which the system is effective depends upon the defects in the moulding. However the method is more efficient as the vacuum increases. Typical vacuum levels are close to 2.0 Mb absolute.

The combination of heat and vacuum, applied as described here will be sufficient to stabilise the deteriorating fibre/resin structure and allow restoration to its original condition. Thus, whether the problem is simply water penetration, or a more chemically complex problem, a solution can still be achieved.